62-2-4

TECHNICAL REPORT

MEMORANDUM REPORT

M62-13-1

SOME ELEVATED TEMPERATURE TENSILE PROPERTIES OF NONFERROUS ALLOYS MELTING IN THE RANGE 300° TO 1100° F

by

L. M. SMITH

Ordnance Project TB4-002
DA Project 5B93-32-003

December 1961

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FRANKFORD ARSENAL

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SOME ELEVATED TEMPERATURE TENSILE PROPERTIES OF NONFERROUS ALLOYS MELTING IN THE RANGE 300° TO 1100° F

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ABSTRACT

A survey of literature was conducted to compile data on the elevated temperature properties of alloys melting in the range of 300° to 1100° F. A majority of the data found pertained to tin alloys with alloys of lead, aluminum, cadmium, magnesium, and zinc, following in that order. The elevated temperature tensile properties of a total of 64 alloys and 2 pure metals are given in this compilation.

INTRODUCTION

The rapidly changing character of this country's defense requirements over the past few years has caused an ever increasing demand for new and better materials, as well as an expansion in the list of applications for standard engineering materials. In the latter category, this has created a parallel need for a more complete knowledge of metal properties, oftentimes for the purpose of fulfilling unique conditions of service. A recent requirement for information of this type has developed from consideration of comparatively low melting point materials for utilization in a structural application. Frankford Arsenal was requested, in this connection, to survey and compile existing data on the elevated temperature properties of alloys melting in the range of 300° to 1100° F.

PROCEDURE

The data contained in this report were gathered through a survey of existing literature and cover the elevated temperature properties of 63 different alloys and 2 pure metals. During the course of the survey it was found that there were many low melting temperature alloys within the scope of this report for which no elevated temperature tensile property data exist. The reasons for this lack of data may be explained as follows:

a. The primary use of many of the alloys is in the nature of bearing materials. In this respect, compression data are of greater interest and thus only these data were published.

b. Many of the alloys lose all semblance of their room temperature strength at slightly elevated temperatures.

RESULTS

The bulk of the data was found to exist on tin alloys, with alloys of lead, aluminum, cadmium, magnesium, and zinc following, in that order. Several alloys of aluminum and magnesium have melting points slightly in excess of the upper limit of 1100° F. These alloys were, nevertheless, included in the survey.

The data for all but the aluminum alloys are compiled in Tables I through V, and data for the latter are plotted graphically in Figures 1 through 6. Inclusion or omission of certain data was based on the following considerations:

a. Yield Strength - for many of the alloys, no true yield strength exists; in other cases, the yield strength becomes undefinable at an elevated temperature. This explains the absence of yield strength data for many of the alloys listed.

b. Hardness - These data were generally sparse and thus were omitted entirely from this compilation.

c. Melting Point - Melting point temperatures were generally available, with the exception of those for ternary and quaternary alloys of tin. Rough approximations of the melting points of these alloys were made from binary and ternary phase diagrams (where the effect of one constituent on the liquidus temperature was not known). These alloys were listed when the melting points so determined were considered to be within the range of interest. A determination of the melting point of these alloys can be made from cooling temperature vs time curves of specially prepared alloy melts.

d. Miscellaneous - Information on material form, the rate of straining, time at temperature prior to testing, etc., have been included whenever this information was available in the literature.

In the utilization of the data on any of the alloys covered in this report, careful attention should be paid to the units of elongation. These units may be given in (a) percent in 2 inches, (b) percent in 0.866 inch, (c) percent in an unspecified length, (d) percent on $4\sqrt{\text{area}}$.

TABLE I. Elevated Temperature Tensile Properties of Tin and some of its Alloys

Commercial Designation	% Sn	% Principal Alloying Elements Ag	Cd	Cu	Pb	Sb	Melting Point (°F)	Test Temp (°F)	Strength (Kips) Tensile	Yield	Elongation (% in 2 in.)*	Remarks
Pure	100						450	59	2.17		75[a]	Rate of straining:
								122	1.79		85[a]	0.4 in./in./min
								212	1.59		55[a]	
								302	1.09		55[a]	
								392	0.65		45[a]	
Alloy 2	89			3.5		7.5	669	68	11.20		18[b]	Chill cast
								120	9.20		24[b]	
								212	6.50		23[b]	
								300	4.00		32[b]	
								345	2.90		38[b]	
-	60				40		374	67	8.1		50	
								302	2.0		140	
-	87		10	3			n/a[c]	302	6.1		19	
-	83		10	7			n/a	68	17.7		6	
								302	7.4		19	
-	80		10	10			n/a	68	18.8		3	
								302	7.4		14	
-	77		10	13			n/a	68	21.0		2	
								302	7.8		9	
-	84		13	3			n/a	302	6.3		23	
-	77		13	10			n/a	68	20.7		3	
								302	7.8		12	
-	74		13	13			n/a	68	21.7		2	
								302	8.1		8	
-	73		17	10			n/a	68	21.2		2	
								302	7.5		16	
-	70		17	13			n/a	68	21.6		3	
								302	8.1		7	
-	70		20	10			n/a	68	20.6		4	
								302	7.4		17	
-	94		5	1			n/a	302	4.4		44	
-	92		5	3			n/a	302	5.7		24	
-	90		5	5			n/a	302	5.9		24	
-	88		5	7			n/a	302	6.2		20	
-	85		5	10			n/a	68	17.9		5	
								302	7.1		17	
-	82		5	13			n/a	68	20.2		3	
								302	7.2		10	
-	90		7	3			n/a	302	6.0		18	

* except as noted
(a) % in 0.866 inches
(b) % in $4\sqrt{Area}$
(c) not available

TABLE I. Elevated Temperature Tensile Properties of Tin and some of its Alloys (Cont')

Commercial Designation	% Sn	% Principal Alloying Elements Ag	Cd	Cu	Pb	Sb	Melting Point (°F)	Test Temp (°F)	Strength (Kpsi) Tensile	Yield	Elongation (% in 2 in.)*	Remarks
-	86		7	7			n/a	302	6.5		23	
-	83		7	10			n/a	68	17.7		6	
								302	7.2		10	
-	80		7	13			n/a	68	19.7		3	
								302	7.5		10	
-	77		13	5		5	n/a	68	23.5		5	
								302	6.5		27	
-	72		13	10		5	n/a	68	25.2		2	
								302	6.5		27	
-	71.5	0.5	13	10		5	n/a	68	24.6		2	
								302	7.2		14	
-	76.5	0.5	13	5		5	n/a	68	23.1		5	
								302	7.3		20	
-	76.5	0.5	13	10			n/a	302	8.1		14	
-	92.4			3.5	0.3	3.8	n/a	64	9.5	7.6	20[b]	Strain rate: 0.013 in./min; Rod, chill cast from 840° F.
								122	8.1	6.4	26[b]	
								212	5.3	4.4	25[b]	
								302	3.8	2.6	32[b]	
								347	2.7	1.6	26[b]	
-	91.4		1	3.5	0.3	3.8	n/a	64	14.4	11.2	9[b]	As above; chill cast from 1020° F.
								122	11.0	8.1	16[b]	
								212	7.7	5.7	20[b]	
								302	4.3	2.9	45[b]	
								347	3.0	1.9	63[b]	
-	89.2			3.2	0.5	7.1	n/a	68	11.2	8.2	18[b]	As above; chill cast from 750° F.
								122	9.2	6.6	24[b]	
								212	6.5	4.8	23[b]	
								302	4.0	2.5	32[b]	
								347	2.9	1.6	38[b]	
-	85.6			4.2	0.3	9.9	n/a	64	13.2	10.5	13[b]	As above; chill cast from 840° F.
								122	11.1	8.6	17[b]	
								212	8.1	6.2	23[b]	
								302	4.9	3.9	33[b]	
								347	3.1	2.5	52[b]	
-	84.6		1.0	4.2	0.3	9.9	n/a	64	16.2	13.0	8[b]	As above; chill cast from 1020° F.
								122	13.2	10.0	13[b]	
								212	8.0	6.4	23[b]	
								302	5.0	2.6	29[b]	
								347	4.0	1.9	45[b]	
-	82			4	4	10	n/a	68	13.9	9.9	16	Strain rate: 0.013 in./min; chill cast from 840° F.
								122	10.2	7.1	13	
								212	6.5	5.0	18	
								302	3.5	2.2	21	
								347	2.2	1.2	33	

* except as noted
(a) % in 0.866 inch
(b) % in 4 $\sqrt{Area}$
(c) not available.

TABLE II. Elevated Temperature Tensile Properties of Lead and some of its Alloys

Commercial Designation	% Pb	Principal Alloying Elements (%) As	Cu	Sb	Sn	Melting Point (°F)	Test Temp (°F)	Tensile Strength (Kips)	Elongation (%)	Remarks
Pure	100					621	68	1.92	31	Cast and annealed at 212°F
							180	1.14	24	
							302	0.71	33	
							383	0.57	20	
							509	0.28	20	
SAE 13	85			10	5	493	75	10.0	5	Chill cast
							212	4.9	30	
SAE 14	75			15	10	514	75	10.5	4	Chill cast
							212	5.5	25	
							300	3.0	52	
SAE 15	83	1		15	1	667	75	10.4	2	Chill cast
							212	6.4	9	
							300	3.7	26	
							392	1.3	95	
"G" Babbitt	83.5	3		12.25	0.75	595	75	9.8	1.5	Chill cast
							212	6.7	4.0	
							300	4.2	10.0	
							392	1.9	70.0	
Alloy 8	80			15	5	522	64	11.2	8	Chill cast from 840° F; rate of straining: 0.013 in./min.
							122	9.4	18	
							212	5.8	35	
							302	2.9	66	
							347	1.6	100	
ASTM-5B	95				5	595	77	3.2	55	
							302	1.5	65	
ASTM-20B	80				20	531	75	5.4	25	
							212	1.9	70	
ASTM-70A	70				30	496	75	6.2	40	
							212	1.9	120	
ASTM-50A, 50B	50				50	421	77	7.0	60	
							302	1.9	145	
-	90				10	570	77	4.1	35	
							302	2.1	45	
-	85				15	550	75	4.9	15	
							212	2.0	20	
-	60				40	460	75	6.0	60	
							212	1.9	140	
-	48.7		1	10.5	39.8	n/a	75	10.6	16[a]	Chill cast from 840° F. rate of straining: 0.013 in./min
							100	8.0	18[a]	
							200	4.5	33[a]	
							300	1.3	85[a]	

[a]on $4\sqrt{\text{area}}$

TABLE III. Elevated Temperature Tensile Properties of some Cadmium Alloys

Commercial Designation	Principal Alloying Elements (%) Ag	Cu	Ni	Melting Point* (°F)	Test Temp (°F)	Tensile Strength (Kips)	Elongation (% in 2 in.)	Remarks
-			1.3	752	82	16.4	19	Cast
					212	10.5	36	
					392	3.3	111	
					572	0.6	162	
-			3.0	860	82	22.9	6	Cast
					212	14.3	13	
					392	3.3	65	
					572	0.7	213	
-	2	0.5		700	Room	18.0	50	Cast
					212	12.0	-	
					300	8.0	-	
					400	4.4	68	
-	5.0			752	Room	16.4	31	Rod, 1/4 in. dia
					300	4.4	94	
					425	2.6	94	
					500	1.7	22	

*Approximate

TABLE IV. Elevated Temperature Tensile Properties of some Magnesium Alloys

Commercial Designation	Principal Alloying Elements (%) Al	Mn	Zn	Melting Point (°F)	Test Temp (°F)	Strength (Kips) Tensile	Yield	Elongation (%)	Remarks
AM100A-T6	10	0.10	0.30	1100	Room	40.0	22.0[a]	1	
					300	24.0	9.0	4	
					400	24.0	6.5	25	
					500	12.0	4.0	45	
					600	8.5	2.5	60	
					700	5.5	1.5	00	
AZ91C-T6	8.7	0.13	0.7	1105	70	40.0	21.0	6	
					300	27.0	14.0	40	
					400	17.0	12.0	40	
AZ92A-T4	9.0	0.10	2	1100	72	40.0	14.0	10	
					200	40.0	-	8	160 days at temp.
					300	26.0	-	40	160 days at temp.
					400	17.0	-	41	160 days at temp.
					500	11.0	-	52	40 days at temp.

[a]0.2% offset

TABLE V. Elevated Temperature Tensile Properties of some Zinc Alloys

Commercial Designation	Principal Alloying Elements (%) Al	Cu	Mg	Melting Point (°F)	Test Temp (°F)	Tensile Strength (Kips)	Elongation (% in 2 in.)	Remarks
AG40A	3.9	0.25	0.06	728	70	41.0	10	Die cast
					140	35.5	16	
					203	28.3	30	
AG41A	3.9	1.0	0.06	727	70	47.6	7	Die cast
					104	42.9	13	
					203	35.1	23	

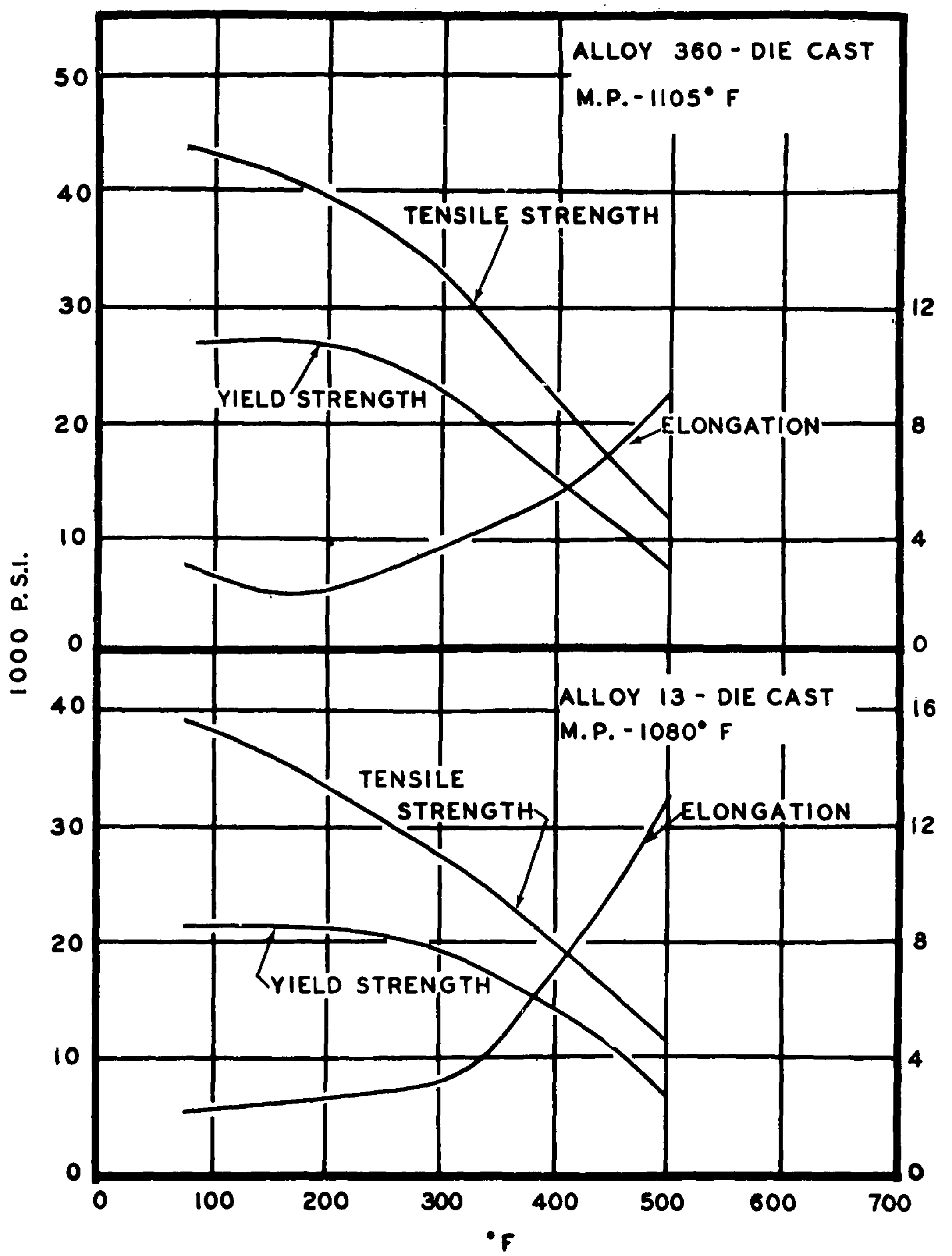

Figure 1. Elevated Temperature Tensile Properties of Aluminum Alloys 360 and 13

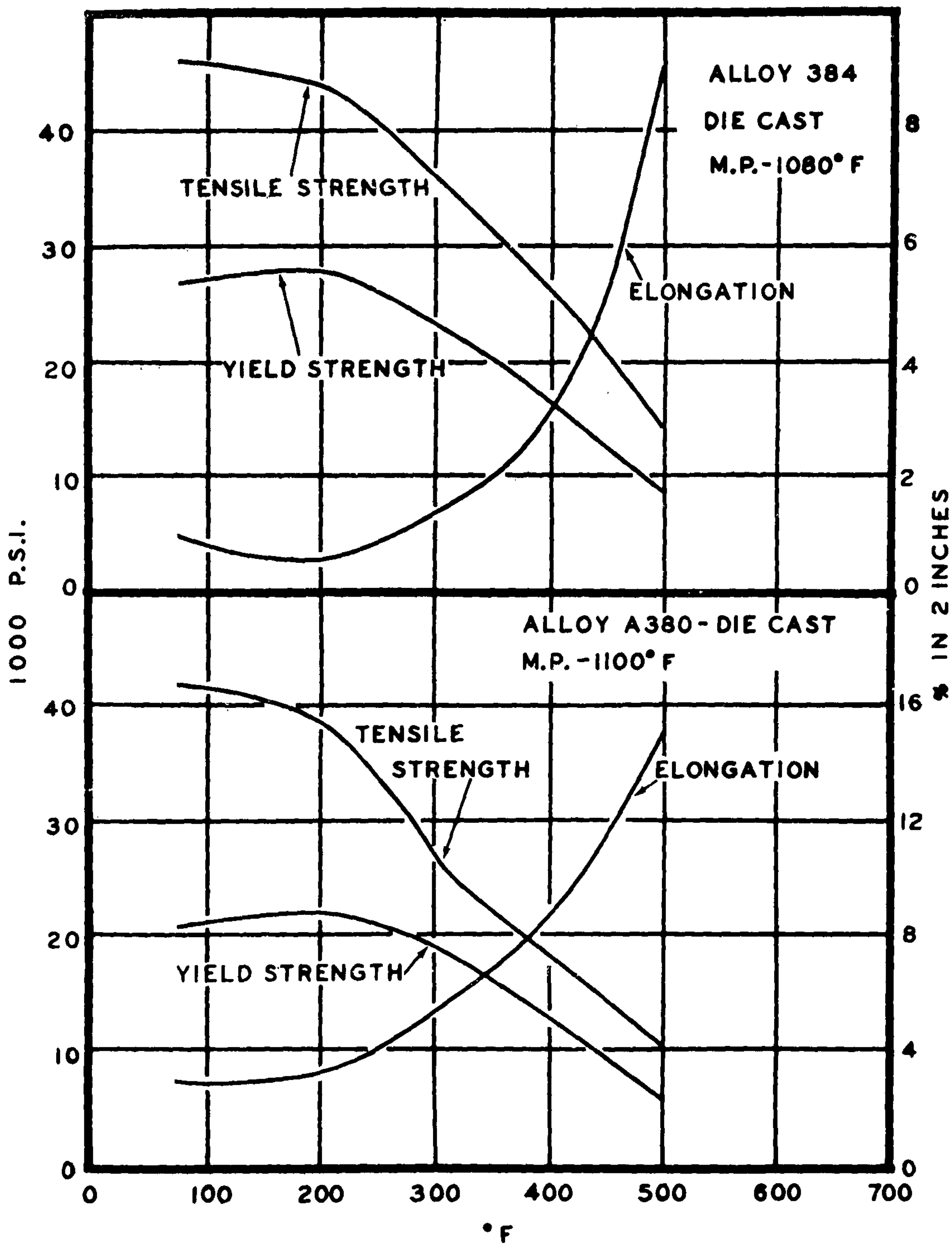

Figure 2. Elevated Temperature Tensile Properties of Aluminum Alloys 384 and A380

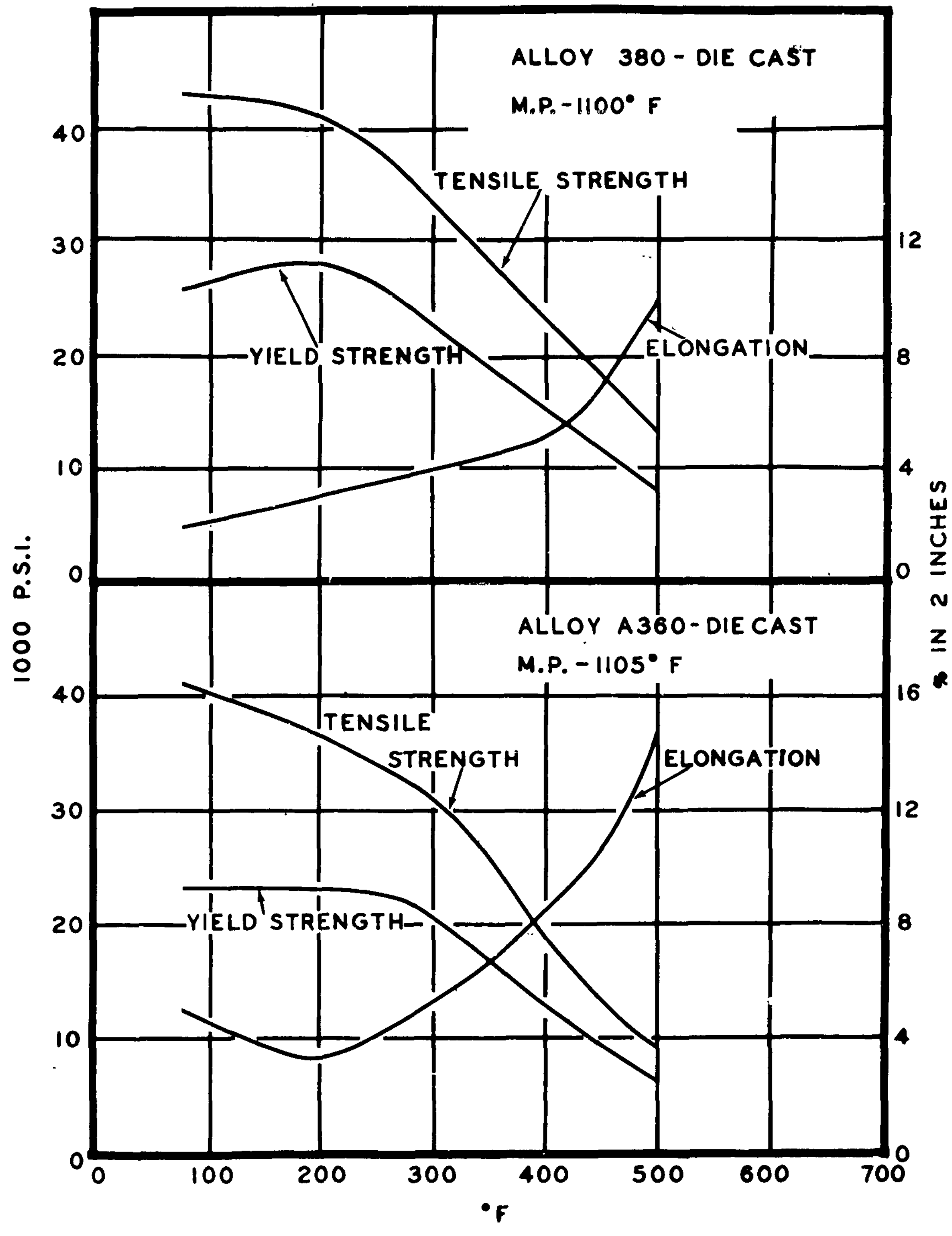

Figure 3. Elevated Temperature Tensile Properties of Aluminum Alloys 380 and A360

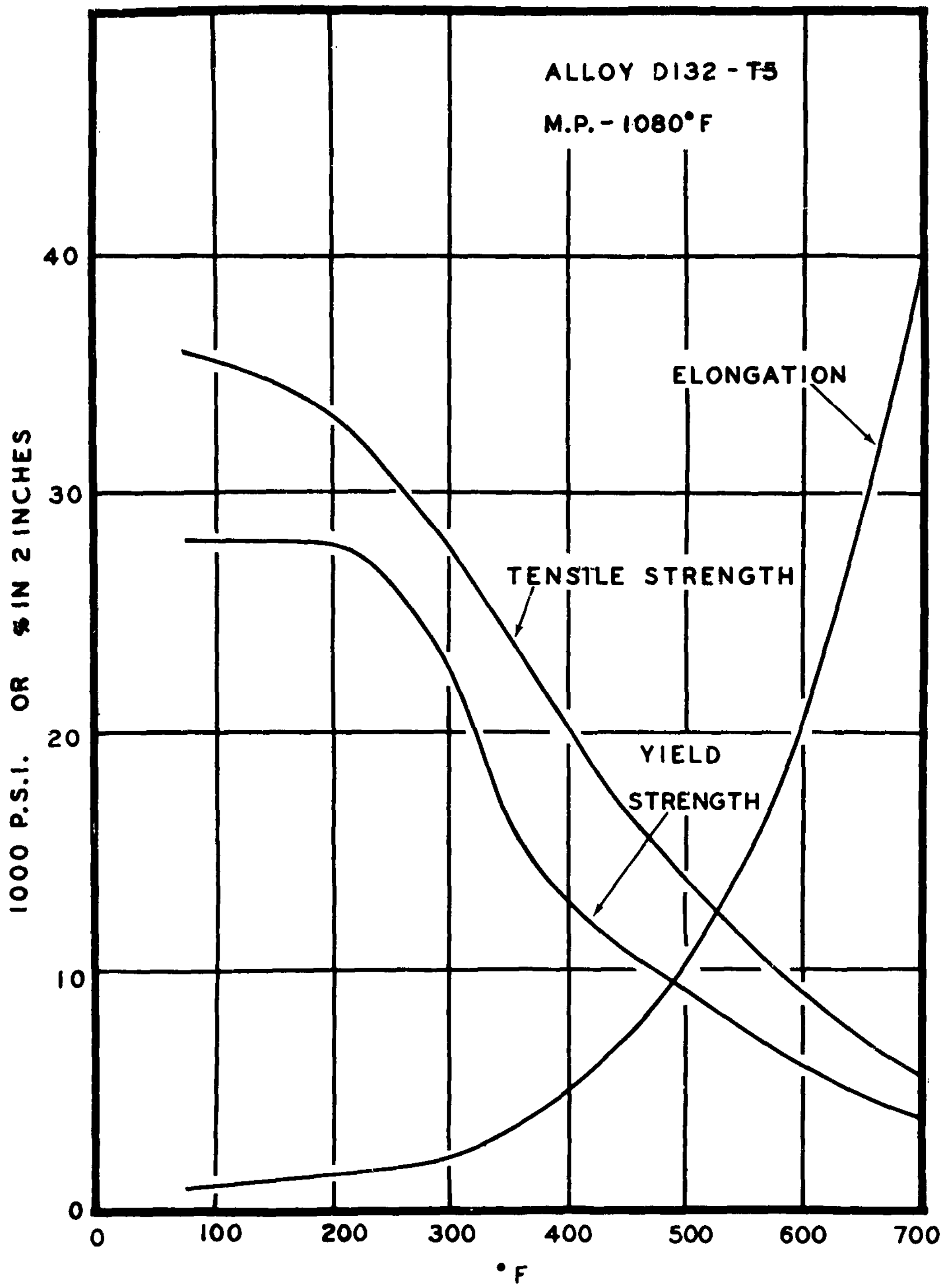

Figure 4. Elevated Temperature Tensile Properties of Aluminum Alloy D132-T5

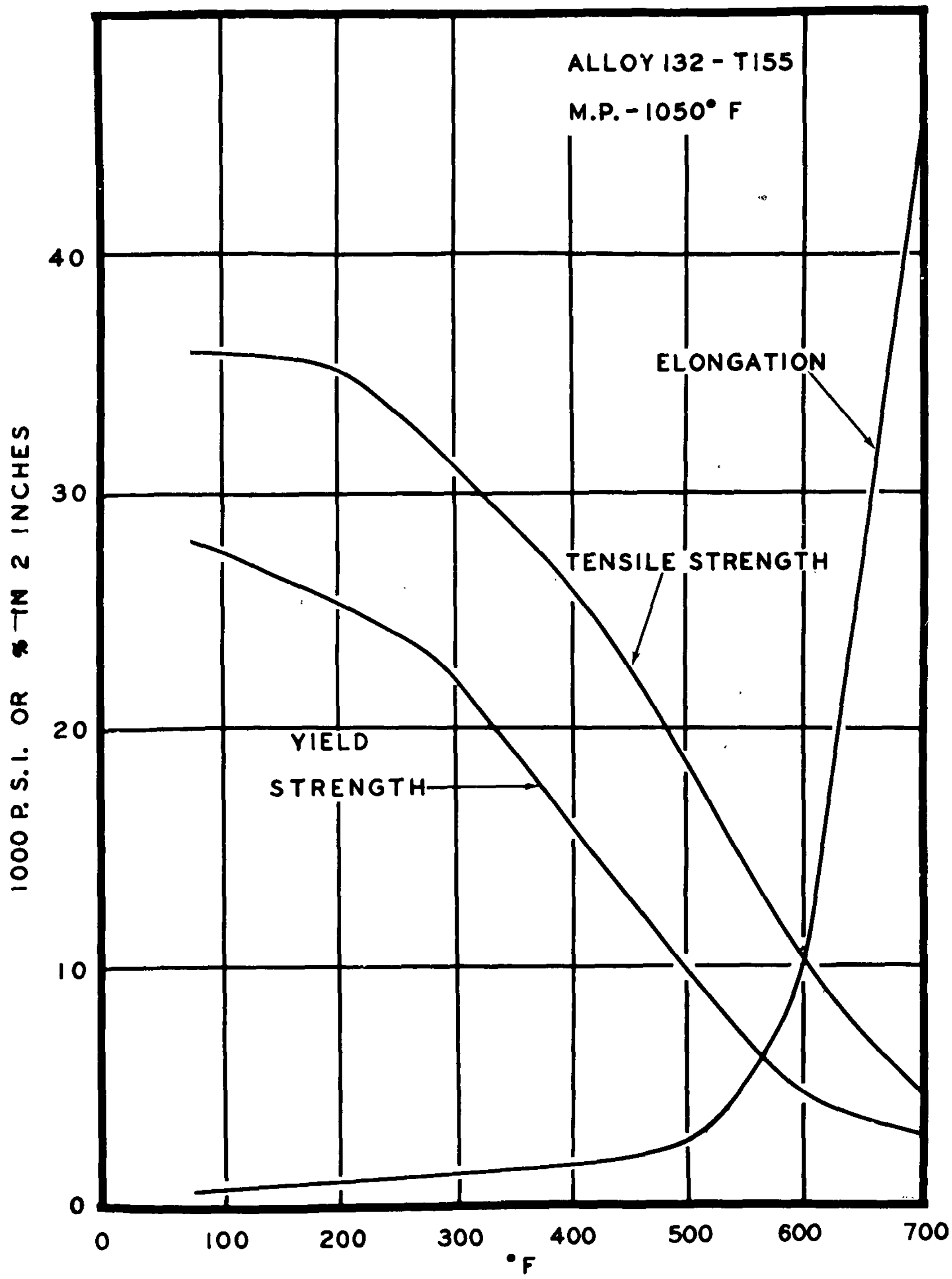

Figure 5. Elevated Temperature Tensile Properties of Aluminum Alloy 132-T155

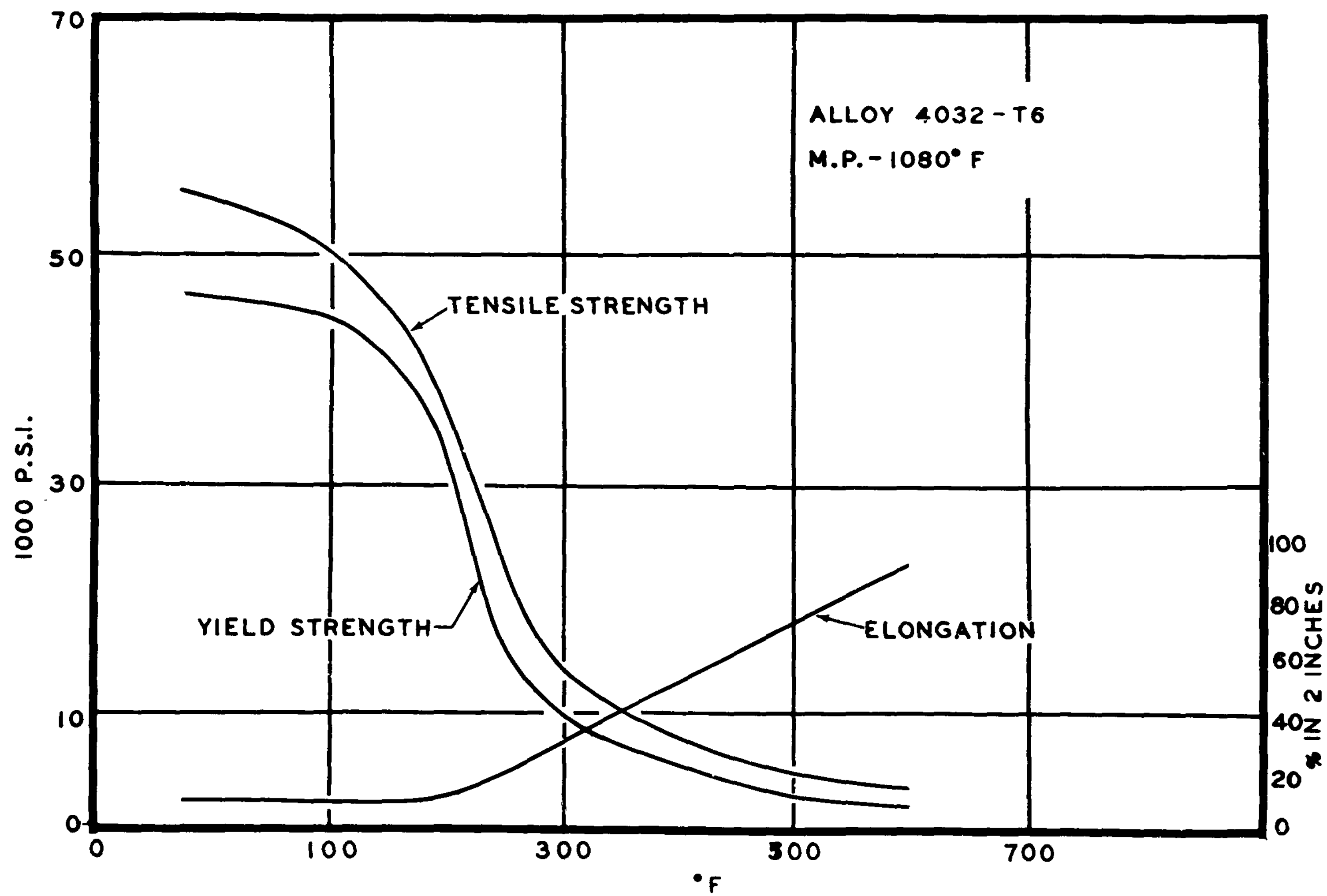

Figure 6. Elevated Temperature Tensile Properties of Aluminum Alloy 4032-T6

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Report M62-13-1, Dec 61 17 pages incl tables & illus.
DA Project 6B93-32-003 OCO Project TB4-002

A survey of literature was conducted to compile data on the elevated temperature properties of alloys melting in the range 300° to 1100° F. A majority of the data found pertained to tin alloys with alloys of lead, aluminum, cadmium, magnesium, and zinc following, in that order. The elevated temperature tensile properties of a total of 64 alloys and two pure metals are given in this compilation.

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1. Nonferrous Metals
2. Low Melting Point Alloys
3. Elevated Temperature Tensile Properties

I. Smith, L. M.
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